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Dear Ron,

In order to complete my ONR grant entitled, "Survey of ship tracks observed by NOAA AVHRR," I am sending three copies of the Final Technical Report to you with copies distributed as indicated below. Included is a completed Report Documentation Page (SF 298).

Sincerely,

James A. Coakley, Jr.

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FINAL TECHNICAL REPORT

ONR Grant # N00014-95-1-0405

SURVEY OF SHIP TRACKS OBSERVED BY NOAA AVHRR

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1-km Advanced Very High Resolution Radiometer (AVHRR) observations from the morning, NOAA-12, and afternoon, NOAA-11, satellite passes over the coast of California during June 1994 were analyzed to determine the altitudes, visible optical depths, and cloud droplet effective radii for low-level clouds. Comparisons were made between the properties of clouds within 50 km of ship tracks and those farther than 200 km from the tracks in order to deduce whether any special conditions were required for the appearance of ship tracks in satellite images. The results indicated that the low-level clouds must be sufficiently close to the surface for ship tracks to form. Ship tracks rarely appeared in low-level clouds having altitudes greater than 1 km. Contrary to what might be suggested from theories concerning the susceptibility of cloud modification due to increases in the number of particles in the environment, the distributions of visible optical depths and cloud droplet effective radii for ambient clouds in which ship tracks were imbedded were found to be the same as those for clouds without ship tracks. Cloud droplet sizes and liquid water paths for low-level clouds do not seem to constrain the appearance of ship tracks in the imagery. The sensitivity of ship tracks to cloud altitude appears to explain why the majority of ship tracks observed from satellites off the coast of California were found south of 35°N. A small rise in the height of low-level clouds appeared to explain why numerous ship tracks appeared on one day in a particular region, but disappeared on the next, even though the altitudes of the low-level clouds were generally less than 1 km and the cloud cover was the same for both days. In addition, ship tracks were frequent when low-level clouds at altitudes below 1 km were extensive and completely covered large areas. The frequency of imagery pixels overcast by clouds with altitudes below 1 km is greater in the morning than in the afternoon and this difference explained why more ship tracks were observed in the morning than in the afternoon. If the occurrence of ship tracks in satellite imagery data depends on the coupling of the clouds to the underlying boundary layer, then cloud top altitude and the area of complete overcast by low-level clouds may be useful indices for this coupling.

List of publications that were a result of this research project.

Coakley, J.A., Jr., P.A. Durkee, K. Nielsen, J.P. Taylor, S. Platnick, B.A. Albrecht, D. Babb, F-L. Chang, W.R. Tahnk, C.S. Bretherton, and P.V. Hobbs, 1997: The appearance and disappearance of ship tracks on large spatial scales. *J. Atmos. Sci.* (Accepted for publication).

Taylor, J.P., M.D. Glew, J.A. Coakley, Jr., W.R. Tahnk, S. Platnick, P.V. Hobbs and R.J. Ferek,
1997: The effects of aerosols on the radiative properties of clouds. *J. Atmos. Sci.*
(accepted for publication)